THE

VALVULAR STRUCTURE

OF

THE VEINS,

ANATOMICALLY AND PHYSIOLOGICALLY CONSIDERED,

WITH A VIEW TO EXEMPLIFY OR SET FORTH,

BY INSTANCE OR EXAMPLE,

THE

WISDOM, POWER, AND GOODNESS OF GOD,

AS REVEALED AND DECLARED IN

HOLY WRIT.

THE WARNEFORD PRIZE ESSAY,

FOR THE YEAR 1838.

BY

THOMAS CLARKE RODEN,

STUDENT OF THE BIRMINGHAM ROYAL SCHOOL OF MEDICINE AND SURGERY.

Ὁ γὰρ εὐσεβῶν ἄκρως φιλοσοφεῖ.

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1839.

TO THE

REV. SAMUEL WILSON WARNEFORD, LL.D.

RECTOR OF BOURTON ON THE HILL,

WHO

AMIDST HIS DAILY LABOURS OF LOVE

FOR THE RELIEF OF BODILY AND MENTAL DISEASES

AND THE

SUPPLY OF SPIRITUAL AND TEMPORAL WANTS

DISCOVERED

NEW FIELDS OF EXERTION IN SCHOOLS OF PHYSIC, AND

UNTRODDEN PATHS OF BENEVOLENCE

IN THEATRES OF ANATOMY,

AND BY THE INSTITUTION OF ANNUAL PRIZES

IN THE

BIRMINGHAM ROYAL SCHOOL OF MEDICINE AND SURGERY,

AND IN THE

MEDICAL DEPARTMENT OF THE KING'S COLLEGE, LONDON,

HAS ENCOURAGED

THE CONTEMPLATION OF THE DIVINE ATTRIBUTES

UNDER THE CONCENTRATED RAYS OF

REVEALED AS WELL AS NATURAL RELIGION,

AND BY THESE MEANS

HAS ENDEAVOURED TO STAMP A CHRISTIAN CHARACTER

UPON THE

STUDIES OF ANATOMY AND PHYSIOLOGY,

TO HIM

THE DOER OF GOOD TO ALL MEN ACCORDING TO THE MEASURE OF HIS POWER,

THIS ESSAY,

THE FIRST ATTEMPT TO CARRY INTO EFFECT HIS PIOUS AND BENEVOLENT INTENTIONS,

IS DEDICATED,

WITH GREAT DEFERENCE TO HIS JUDGMENT AND SINCERE RESPECT FOR HIS VIRTUES,

BY HIS MOST OBEDIENT SERVANT,

THOMAS CLARKE RODEN.

Birmingham,
April 19, 1839.

ARGUMENT.

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ERRATUM. p. 37. *for* portal *read* fœtal

ESSAY.

Introductory remarks.

It has been proposed by the respected Founder of this Annual Prize, that the subject of the Essay should be taken out of any branch of Anatomical, Physiological, or Pathological Science; that it should be handled in a practical or professional manner; and that it should be made available for the attestation of those divine attributes of power, wisdom, and goodness, which the Scriptures have revealed, and which are variously exhibited and exemplified in the wonders of the human frame.

Impressed with the defectiveness of our perceptions, when employed upon those vast and varied fields which have been submitted to our contemplation, and with the impotence of our feeble powers to fathom the incomprehensible and mysterious workings of the Deity, it is with diffidence I enter upon an undertaking, at once so interesting in itself, and so important in all its bearings and relations.

Without presuming to enquire into those things, which are obviously to us as a sealed book, (being purposely hidden from our view,) it must be admitted, that there still remains an extensive region

of nature within the reach of our reason and senses, and which may be made serviceable for religious, as well as philosophical, investigation. For all things natural conduct the enquirer to their Builder and Maker, God[a]; to that supreme Being, whose power, like all his other attributes, is infinite; and in nothing is that power more fully and strikingly displayed than in the construction of the human body. Every constituent of that beautiful fabric co-operates with the nicest harmony, and most complete efficiency, in the fulfilment of the ends intended, and there is no part of its marvellous mechanism, which supplies a more decided evidence of design, than that which has been proposed specially as the subject of this Essay, the valvular provisions of the veins.

On the sanguiferous system in general.

A solid frame-work is formed by the bones, which are so shaped as to be light by their porous or tubular structure, and powerful by their principles of action; which combine elegance of proportion, with strength and freedom of motion; and are capable of being moved in any direction which may be requisite to provide for the necessities or increase the comforts of the living being. But these structures require support, and it is by the sanguiferous system, that they receive not only support, but nutrition, growth, and reparation; and that system would not work for the accomplishment of any of these purposes, were it not for this wise and merciful apparatus of valves.

[a] Heb. xi. 10.

The adaptation of this system to the necessities of the creature, is complete throughout all the gradations of organic life. If we descend to the lowest ranks of Zoophytes, and view the analogy which exists between their mode of nutrition, and that provided for the vegetable kingdom; and the manner of *nourishment by imbibition*, found in the simpler kinds of Polypi, Infusoria, Medusæ, &c.; and if we then proceed to contemplate the establishment of the vascular circulation in the animals composing the class of Annelides; or advance to the tribe of Lumbrici, (in which the first rudiments of that organ are to be found, which in the higher classes of animals performs the important functions of the heart, but which here presents itself in the shape of globular dilatations or bulbs, accelerating, no doubt, by their muscular contraction, the current of the circulating blood;) if after this, we prosecute our enquiry into classes of more highly organized beings, as in the Decapoda, (comprehending the Lobster and Crab family,) we find this part dilated into a globular organ, situated under the shell of the dorsal region of the thorax, pulsating regularly, and vigorously propelling its contents into the circulating vessels, which may now be distinguished into arteries and veins.

Comparative views of it in the lower grades of life.

The rudiments of a heart.

The importance of this organ increases as we ascend still higher in the scale of animal organization. If we trace the footsteps of nature, from the winged insect, to the superior order of vertebrata, these constructions of creative power will be found

to be manifested by progressive steps, and at last they are exalted to the very summit of elaborate and refined developement in Man, who stands pre-eminent, the image of his Creator, and the delegated Lord of things created.

Circulation of the blood in man.

In man, the blood, after it has been conveyed from the left side of the heart, throughout the body, by the arteries, and diffused over its most remote and minute portions, by their innumerable ramifications, is by another set of vessels, brought back, exhausted and contaminated to the centre of the circulation, in order that it may be renovated by aeration, and the products of digestion, and thus again fitted for the various purposes of another diffusion. The veins are the channels by which these repeated returns and renewals of the blood are effected.

The veins.

The veins are a set of tubes, differing materially from the arteries, both in number, size, and organization. Three tunics enter into the formation of a vein, each of which has a structure, properties, and uses, different from its fellows.

Three tunics.

External tunic. Tunica cellulosa.

The external coat, stronger than the others, consists of condensed cellular tissue. This element is known to be largely employed in the formation of animal structures, and is as varied in its conditions, as universal in its use and application.

Of the cellular tissue in general.

It would be irrelevant to the subject to enter fully into the minute anatomy of the cellular membrane; or to cite at length the various doctrines maintained by physiologists upon its nature. Suffice it to say, that although it has been contended, on

the one hand, that this structure is composed of white vessels, or of fasciculi of tubes; and on the other, that it is an homogeneous, viscid, tenacious substance, without assignable form; (while others again have conceived it to be formed of minute globules;) it is now generally agreed that it is made up of an infinitude of extremely thin, transparent lamellæ, crossing each other, and interlaced by numberless white cylindrical filaments, which leave compartments or cells, of various sizes and shapes, communicating with each other, and permitting the diffusion of air and fluids, as is seen in anasarca and emphysema. Anatomical characters.

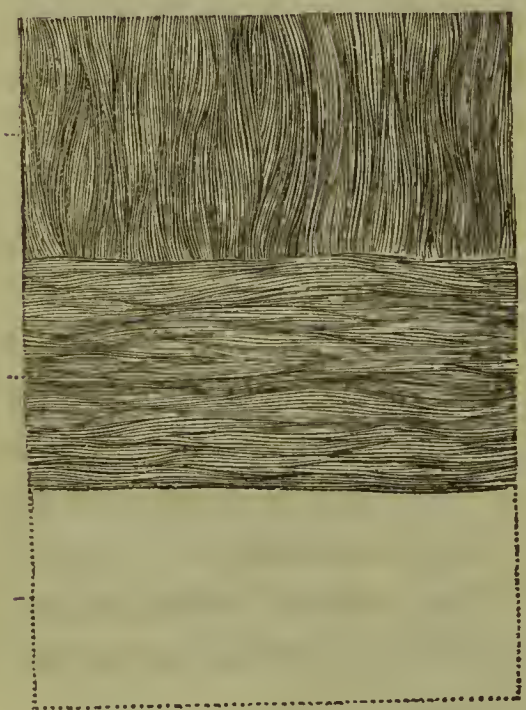
Cellular tissue possesses great elasticity, extensibility, and flexibility. Hence it is admirably adapted to the many prompt and violent exertions necessary for the safety and well-being of man. If it be still further analyzed, it will be found to be almost entirely made up of gelatine, with some albumen and animal mucus; to this may be attributed its great elasticity, for a preponderance of albumen would have rendered it less elastic. But enough may have been said respecting the nature of the tissue forming the outer coat. Physical properties.

The middle tunic consists almost wholly of longitudinal fibres, some few assuming a transverse direction[b]. This tunic differs in a marked manner Middle coat. Tunica media, or Tunica propria.

[b] "Sed non tantum ex fibrarum longitudinalium, verum etiam circularium stratis constat, quæ singulæ tenui lamellâ tunicæ cellulosæ disjuncta sunt." *Marx*, p. 26.

"In avibus fibras facillime discernendas esse observarunt." *Cuvier*, l. c. iv. p. 121.

from that of the arteries, which is composed of well-defined circular fibres, by some authors supposed to be muscular; but by others to be something similar to the *tissu jaûne* of the French physiologists. The venæ cavæ, however, at their termination are provided with distinct muscular fibres, which have a circular arrangement, and appear to be prolonged from the auricle[c]. For illustration I subjoin part of the ascending vena cava, shewing the circular fibres which it derives from the auricle.



a. longitudinal fibres.

b. circular.

c. living membrane.

This tunic is also thinner than that of the arte-

[c] "Musculum trapezium et annularem Cavæ inferioris autem: levatorem majorem, constrictorem cavarum communem et levatorem minorem. *Soemmerring.*

"Venæ cavæ ac pulmonales circa suas in sinus insertiones distinctis fibris muscularibus gaudent, *manifesto quoque micant,* sanguinemque in sinus detrudent. Quin ipsæ post perfectam ventriculorum ipsorumque sinuum quietem, vim vitæ diutius retinent." *Soemmerring,* l. c. p. 333.

ries; it is stronger in the superficial veins, such as are immediately beneath the teguments, than in those more deeply seated; it is also more strongly developed in the vena cava inferior, and in the branches which contribute to its formation, than in the vena cava superior, and its tributaries[d]; This tunic is also more discernible in the smaller branches than in the trunks; hence, dilatation of them happens less frequently, on account of the greater proportionate thickness of their parietes. It is more tenuous than that of arteries, possesses much greater extensibility, and is capable of much resistance, for it requires considerable force to break it.

The internal coat. Tunica interna.

The internal coat is a thin, shining membrane, which pervades the whole venous system, and is continuous with that which lines the auricles; its surface being perfectly smooth, to permit the easy and unrestrained passage of the blood, and with as little retardation as possible from the effects of friction against the parietes of its channel.

Physical properties.

This internal coat of the veins possesses properties, which differ in many important particulars from those of the inner lining of the arteries. It is

[d] "In systemate inferioris venæ cavæ semper est tunica propria *crassior*, quam in systemate superioris. Neque negaverim hoc discrimen eo ipso effici, quod homo erectus incedit et igitur majori robore inferiorum partium opus est ad promovendum sanguinem. Cui observationi illud quam maxime favet, quod in sectione pavonis, vaccæ, tauri, et lupi inveni, ubi nullum discrimen totius systematis venæ cavæ observari." *Marx*, 'de structura atque vita venarum,' p. 27.

thinner, more extensible, and less easily lacerated. But its most prominent and distinguishing feature, and that which cannot fail to fill the mind of the beholder with admiration, is, its forming in different parts of its course a number of little *duplicatures*, which, from the nature of the office they perform, are termed VALVES.

Of valves in general.

The Almighty, in the merciful foresight of his wisdom, has attached to the inner surfaces of many of the vessels and viscera of the body, a peculiar set or system of parts, which may be called valvular, as being designed for the same sort of use as the hydraulic apparatus, which, whilst it freely permits the ascent of some ascending fluid, effectually prevents its descent, (as in the instance of the valve of a piston;) or which, with the like freedom, allows the onward flow of a current of water, but opposes its reflux, of which the valve-gate is an example. The uses of this valvular mechanism, in different parts of the human body, is, to facilitate the onward progress of whatever ought to advance, for the well-being of the individual, and to resist its return or regurgitation.

The special ends of these wonderful and most diversified valves, are as various as their forms. The food in its descent to the stomach has to pass over the Larynx, (the Glottis;) a valve (the Epiglottis) is accordingly provided, for the double purpose of securing a transmission of the masticated food over this orifice, and of permitting the inhalation of air directly afterwards. When the aliment

ary bolus has arrived in the stomach, it is there retained during the period requisite for its digestion and conversion into chyme; after which it approaches the pyloric extremity of the stomach, in order to pass into the intestine. But the pylorus is guarded by a valve, or circular fold of the lining membrane of the stomach, strengthened by a ring of muscular fibres. This valve permits the unrestrained transmission of chyme into the duodenum, but when an indigested morsel presents itself, it refuses a passage, and contracts with such firmness as to cause considerable pain. This faithful guardian allows the free progress of such matters as will conduce to the weal of the animal, while it rigidly denies a passage to such as are unfit and may be injurious; and will often force the stomach to reject them by vomiting, rather than allow them to pass in an unprepared state. The small intestines are provided with innumerable folds of the mucous membrane, (valvulæ conniventes,) which answer a purpose of the greatest consequence in the economy. In the *villi* of this mucous surface may be detected countless minute pores, which are the orifices of the lacteal vessels. The valvulæ conniventes, therefore, not only retard the progress of the chyme, but thereby a much greater extent of mucous surface is acquired; that by the union of these means, the nutritious qualities of the chyme may be thoroughly abstracted by the absorbents, before the excrementitious portion is eliminated from the system. Again, when the ingesta have reached that portion of the intestines, where, having

become altogether fæcal, they require extrusion from the system, a valve presents itself, the valve of Fallopius or Ileo-colica, which, by its very peculiar structure, gives a free passage to what is descending into the colon, but shuts up the orifice against any matter that would return into the ileum.

It is by a succession of valves, that the lacteal and lymphatic juices are made to reach their destination in the left subclavian vein ; assisted no doubt by the vis a tergo, and the contractility of the tubes themselves.

The thoracic duct abounds with the same sort of apparatus. The chyle is thus assisted in its upward course ; whilst, by the peculiarity of the valve where the duct enters the vein, the nutrient juice is made to mix with the blood, not by any continuous outpouring, but by a gentle stillicidium.

It is by the interposition of valves, that the systole and diastole of the heart are carried on without stoppage or disorder ; whilst it receives the blood that circulates through its own substance, through the common orifice of the coronary veins ; but still, by a valve of a very remarkable construction, the blood is prevented from being forced into the vein during the contraction of the auricle.

Valves of the veins.

Other instances of this wise and merciful provision might be selected ; but to proceed to the consideration of the valves of the veins in particular.

Mode of formation.

These valves are so many folds, or prolongations of the common membrane ; all opening in a direction towards the heart. They are for the most part of a semilunar shape, one margin being convex,

and continuous with the lining membrane, and situated farther from the heart than the unattached edge, which being loose and free, falls, or rather floats, back against the side of the vessel, so as to admit the free transit of the blood. Shape of attachments.

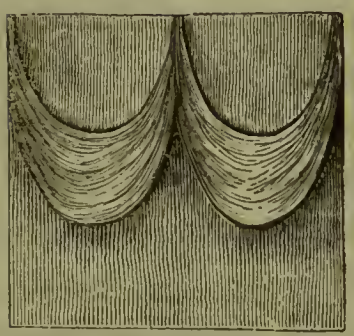
At those points where the valves are attached, the middle tunic is slightly thickened, forming a ridge of the same figure as the margin of the valves, and giving the means of support, and attachment to them. When the internal tunic arrives at this prominent line, it is extended into the interior of the vessel, and then doubled back upon itself, to the point from which it projected ; it then continues its course along the vessel. The valvular tunic, its attachment.

Being thus formed only of two layers of this membrane, inclosing a few transverse fibres [c], and a little delicate cellular tissue, they are necessarily very thin ; insomuch, that when in close apposition with the side of the vessel, they often escape detection ; indeed, so intimately are these two layers united, that there is considerable difficulty in separating them. Its structure internal.

The transverse fibres of the valves, above alluded to, appear to bear considerable analogy to the tu-

[c] " Præter hanc mediam cellulosam telam, quæ duplicem valvulosam membranam ad se mutuo revincit, non raro *fibræ transversæ* cernuntur? tunicæ propriæ fibris similes, valvularum robur insigniter augentes. Hæc substantia a multis membranacea dicitur, quæ tamen non in omnibus se eodem modo habet ; ac qui hoc nomine usi sunt, tricuspidales, ut opinantur ante oculos habuere, quæ, velut aranearum tæla extensæ, ὁκοῖον ἀραχναι διαπετεις, in fibras quasdam tendinosas, membranâ circumdatas, abeunt, ibique versus conum cordis papillulis quibusdam adhærent." *Marx*, p. 37.

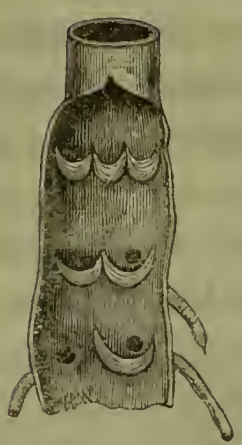
nica propria, or middle coat of veins. These fibres do not appear to be requisite in giving mere support to the column of blood, or in preventing gravitation, or retrogression; for the figure and attachment of the valves are such, as to afford ample security against such occurrences. It is therefore more than probable, these fibres enable the valves themselves to assist in urging forward the column of blood [f].



The transverse fibres of the valves shewn.

Of their size and number.

Although the valves are very constant in their presence in their veins, yet they vary much in their size, number, and situation. Their size is ever found proportionate to the calibre of the canal, or to the number of valves, which are found collected at one particular point. In their distribution, they are subject to much irregularity [g], as is shewn in the accompanying drawing, for which I am indebted to Dr. Roget's work.



[f] "Fibræ transversæ quæ tunicæ propriæ fibris similes eodem fere modo contrahuntur, quo et valvula facilius aperitur et clauditur, *et impetus quodammodo superstanti sanguinis columnæ confertur.*" Hillbrand Physiologie du Sang, p. 143.

[g] "Valvularum numerus et sedes in universum definiri nequit. Aut enim omnino deficiunt, aut reperiuntur interdum,

The valves are disposed either singly, or in rows or groups, of two or three, round the vessel: when singly, they are so constructed, that their loose margin can, when distended, be brought into contact with the opposite side of the vessel; when in rows, they are so arranged, as to meet in the axis of the canal, presenting an impassable barrier to the retrogression of the circulating fluid. In the small veins, they are generally found insulated, (as is the case in the hand and foot,) and in greater numbers: in the larger trunks they are more sparingly distributed, and more frequently disposed in pairs.

Not universal in their distribution.

The valves are not universal in their distribution, for the veins of the great cavities, (abdomen, thorax, and cranium,) being less subject to unequal pressure, are, for the most part, devoid of valves; exceptions, however, exist, for valves are numerous in the spermatic veins, the azygos vein also, has a valve at its termination, as well as the vena cordis maxima.

Extremities amply supplied.

The veins of the extremities, especially the lower extremities, are amply supplied with valves, as are likewise the facial, and superficial veins of the neck, thorax, and abdomen [h]. Indeed, they are in general

tunc aut numerosæ sunt, aut raræ, aut integræ, aut imperfectæ." *Soemmerring*, l. c. v. p. 330.

[h] "Reperiuntur in majoribus truncis venosis faciei, colli linguæ tonsillarum, artuum*, jugularis externæ, circa finem venæ coronariæ cordis, integumentorum abdominis, in venâ hypogastrica, funiculi spermatici clitoridis, in vena iliaca, crurali, saphena interna et externa, tibiali. Interdum in venis renalibus, raro in vena azyga observantur." *Soemmerring*, l. c. v. p. 329.

* Nicolai de directione vasorum in Hall. Diss. ii. 542. Venas artuum superiorum minus frequenter habere valvulas.

more numerous, as has been before observed, in those veins which run immediately beneath the integuments, and over the muscles, particularly in those parts, which from their depending situation, require them in greater numbers to support, perhaps propel, the ascending column of blood.

Use of the valves.

The use of the valves is apparent, from their very conformation and arrangement. The impulse which the heart, by its powerful contractions, gives to the blood, is nearly expended by the time it has reached the veins; and the blood in these vessels being liable to be retarded by the laws of gravity, and other accessory impediments, it seemed good to infinite Wisdom to provide some means to sustain the pressure of the column of blood, in order to prevent congestion in the capillaries, and the possible stagnation of the whole circulation.

One glance at the situation and structure of the valves belonging to this hydraulic apparatus, is alone sufficient to render fully manifest to the most superficial observer, the perfect aptitude of the means employed, to obtain the required result. It is clear, that wherever these valves exist, the blood can flow only in an onward direction; and that they act as so many barriers to oppose a retrograde motion: for their free edges being nearer the heart than those which are attached to the parietes of the veins, they are readily expanded by the slightest retroversion of the blood; while, on the other hand, these filmy, loose, and pendulous membranes, offer no impediment to the natural course of the stream

of life. For the fuller exposition of this matter, the blood may be conceived to be ascending as by a ladder, to the heart. Under this representation, the valves may be considered steps or stages in its progress, each of which being gained in its turn, sustains the ascending current, and prevents it from receding, to the hindrance of that portion of the stream which is following its steps.

The valves of the veins led to the discovery of the circulation of the blood by Harvey.

It was the observation of these valves, that first suggested to the mind of Harvey the train of reflections which led him to the discovery of the true course of this vital circulation. They may, therefore, be regarded as the means by which the Almighty was pleased to bring to light one of the most valuable facts which adorn the page of science, and from which the life and health of man have derived all those increased securities, which have arisen out of subsequent improvements in the Practice of Medicine and Surgery.

The discovery (for it unquestionably was the discovery of Harvey, whatever may have been the approximations made by his predecessors) has deservedly made him the pride of his country, and the admiration of mankind. For on the momentous fact of the blood's circulation, have hinged results the most important to human life and happiness. This, like many other truths, physical and physiological, met with opposition at the time it was proclaimed; but it soon triumphed over all the obstacles which the hostility of superstition and prejudice, and the malignant opposition of envy,

could throw in its path. This bright and shining discovery was doomed to struggle (but still for a very short time) with the obscurity in which science was then involved. But it soon beamed forth in all its splendour, and dissipated that darkness, and so became at last the guiding star to all those blessings and benefits, which Medical and Surgical science is now able, under God's blessing, to bestow on the sick and suffering.

The wisdom and goodness of God manifested in this valvular apparatus.

When we behold this apparatus, our wonder is only equalled by our gratitude. We are lost in the admiration of the wisdom and goodness displayed in its formation; we are astonished that structures apparently so frail, should year after year, without cessation, continue to fulfil their functions without derangement. Nor is their peculiar conformation less worthy of praise, than their durability; if, instead of the delicate texture of these valves, they were formed more dense and thick, they would offer as much resistance to the onward course of the blood as to its reflux. But as they are wisely constituted, they present no opposition to the current forwards, being closely attached to one side of the vessel; but, in the event of a retrograde movement, their loose edge is dislodged, and being stretched out by the pressure of the blood across the channel, form barriers to its further recess. And here again, we observe the superintendence of a God of mercy and wisdom; for, if it were possible for the weight of the column of blood to reverse or invert the valves, the whole object of this beautiful mechanism

would be destroyed; but, what an effectual preventive against such accidents is to be observed in the attachments of the valves! with what guardian care is danger averted! with what paternal solicitude is the life and well-being of man provided for!!

There is another important provision for the safety and well-being of man to be discovered in the exemption of the valves from calcareous deposits. In this the valves partake of the immunity of the common membrane of the veins; but the case is different with respect to that of the arteries; for, while the latter almost invariably become more or less ossified in the aged subject, the former is rarely the seat of such a deposit of calcareous phosphates. The organization of the venous common membrane does not appear to admit of it, for that which lines the pulmonary arteries, being a portion of the same tissue, is likewise exempt from ossific impregnation.

The valves are peculiarly useful, as agents for the prevention of hæmorrhage, in cases of wounds, either accidental or surgical. Without them, the blood poured out by collateral branches into the wounded vessel, would, of course, flow towards the branch in the parietes of the vein, and an extensive and dangerous effusion would be the consequence. When viewed under this relation, they may be said to supersede the necessity of applying ligatures to veins, an alternative which exposes the part to the danger of phlebitis.

But to return to the consideration of the veins themselves, and specially of the venous tunics.

Farther consideration of the venous tunics.

It will be seen, that each of the tunics of the veins possesses characteristics, no less striking than peculiar. When viewed as a whole, their organization is manifestly unlike any other structure, in the animal economy. It is here that the perfection of creative art seems to be exerted; and the result is, the production of appropriate vehicles, for the transmission of the vital stream.

Organization of the veins.

The veins, like all other organized structures, must be provided with blood-vessels, and nervous influence, to maintain their own vitality. Their coats are, therefore, furnished with arteries from the contiguous small branches, and are termed *vasa vasorum*. (See drawing.) These minute vessels are so called, by reason of their destination; for they penetrate the walls of the veins, and ramify intimately in their texture; their corresponding veins following nearly the same course with the arteries, in this sub-circulation.

Vasa vasorum.

Nerves of the veins.

They are also provided with nerves, corresponding with the blood vessels[i]; in the cavities, they are derived from the ganglionic system of nerves; and

[i] "Tunica nervea, aut nerveo-vasculosa, nerveo-vasculosæ arteriarum quadrantenus saltem similis, ex stipata constat cellulosa et sanguiferis plerisque vasculis, venarum nutritioni præcipue destinatis, hanc telam adeo perreptantibus, ut cum illa et forte nervulis tunicam modo memoratam construant." *Oudeman*, l. c. p. 10.

in the limbs, from the cerebrospinal. The veins are, however, more sparingly supplied with nerves than the arteries; although the right side of the heart appears to be as liberally supplied with them as the left. It may, therefore, be inferred, that veins require less nervous stimulus to perform their functions, being more subject to the operation of external agencies, than the heart and arteries.

Lymphatics.

With respect to lymphatics, in connexion with the venous structure, although they do not admit of demonstration, there can be no doubt of their existence [k].

Difference between the arterial and venous tunics.

It has been already observed, that in the structure, course, and arrangement, of the veins, there are several particulars, in which they differ essentially from the arteries, independently of that great distinguishing characteristic, the valves, which has been proposed as the special subject of this Essay. They are thinner, more flaccid, less elastic; and are, for the most part, not so deeply seated as arteries, but are comparatively superficial, numbers being situated immediately beneath the integuments. They are, likewise, much more numerous; two veins, in many instances, being found accompanying one artery; independently of the many subcutaneous ones above alluded to. They are also remarkable for the freedom with which they communicate with each other; by means of collateral

[k] "Præsentia *vasorum lymphaticorum* nondum quidem ad oculorum sensum evicta est, sed plusquam verisimilis." *Meckel*, l. c. p. 70.

or cross branches. They are, at the same time, more capacious, as well as numerous, than arteries; and are presumed to contain about two-thirds of the entire mass of the blood.

Physical properties of the veins. 1st, Sensibility.

Among the physical peculiarities of veins, extensibility in their diameter may be enumerated. Arteries are more extensible in a longitudinal direction, than they are transversely; veins, on the contrary, are susceptible of little elongation, but are found to be capable of undergoing a large amount of dilatation. Whether this fact may be, in any measure, accounted for, by the more straightforward course, and diminished tortuosity of the arteries, is perhaps, somewhat problematical. But it may be more readily, and more justly, conceived to be dependent, in a great degree, on their middle coat, which, being composed of circular fibres, may be supposed to admit of extension, more readily in a longitudinal, than in a lateral direction, (being laterally compressed by the circularity of their fibres;) whilst an opposite phenomenon may be imagined to result, in that of veins, from the longitudinal direction, and more scanty distribution, of fibres. However that may be, the dilatation of the veins is sometimes seen to proceed to such an extent, that, at length, their rupture becomes inevitable, from the excessive expansion of their parietes. Indeed, it is by no means uncommon, to see varices of the lower extremities, particularly during pregnancy, from the pressure of the distended uterus on the pelvic veins, and to

witness cases of the most alarming effusion of blood, from their accidental rupture.

2d, Contractility.

The contractility of veins, like their extensibility, is more considerable in the direction of their diameter, than in that of their axis. The influence of cold, in causing their contraction, is very evident; and, on the other hand, the dilatation of them, by the application of heat, is no less palpable. Indeed, the superficial veins are perceptibly affected, by every increase or diminution of temperature; but this fact is so familiarly exemplified in our daily experience, that it is scarcely necessary to advert to it. In the dead subject, the size of the veins is invariably found to be greater or less, according to the quantity of blood they may happen to contain; while an empty vein will be seen collapsed, and apparently of little capacity.

Veins may become fibrous chords.

If a vein no longer carry blood, if, for instance, it be isolated by means of ligature, it will contract, and, at last, degenerate into a mere fibrous chord: and let it here be asked, whether this be not the agency that is instrumental in bringing about the obliteration of the umbilical vein in the fœtus, when birth severs the maternal connexion. Veins, however, cannot be said to be contractile, in the sense in which we speak of muscles; they are devoid of voluntary contractility.

Venous pulsation, what?

There are other particulars connected with this part of the subject, which deserve notice. On the contraction of the right auricle, the whole of the blood is not propelled from its cavity into the right

ventricle, but a portion regurgitates into the veins. Under certain circumstances, this may even be observed in the jugular vein, (viz. in valvular disease of the right side of the heart,) when it is seen to expand, and then to contract, giving an appearance of a slight undulation, which has been termed venous pulsation [1].

3d, Sensibility.

Sensibility is denied to exist in veins, on the ground that various experiments on them are not productive of pain. The ligature, the application of which is occasionally indispensable, does not produce that effect. Neither does the application of mechanical agents, externally or internally, demonstrate the existence of sensibility.

[1] "Neque verus pulsus est, quem descripsimus, neque venarum cavarum et pulmonalium motus, aut alia pauca ea exempla huc trahi possunt, in quibus raris nonnullis mortalibus venæ salierunt. Innumerabiles enim experimentis constat; grandes etiam venas nudas, et suo tumore etiam integram per cutem conspicuas, immutabili diametro in vivo homine vivoque animali persistere" *Haller*, l. c. p. 332.

"Neque rarissimum est, in moribundis aliquam jugularium venarum palpitationem percipi, dum scilicet insuperabile cordi dextro obstaculum sit, dumque sinus dexter sese evacuare non potest in cor, contractus sanguinem in venas contraria directione repellit, easque præter motum dilatat." *Marrher*, l. c. p. 28.

"Quo proprius est morti cor, eo magis augetur causa retropulsionis; frigus enim visque contractilis venarum sanguinem magis magisque accumulat in corde; quo plenius est cor, eo minus aptum est in hocce statu sanguinem retinere, repellit ergo; quo magis repellit, eo magis increscit pulsus venarum; interim vis contractilis venarum quæ sanguinem in corde accumulat, emoritur, emoritur ipsa vis cordis, cessat actio et reactio rhythmi venarum decrescunt donec nulli fiant." *Zimmermann*, l. c. p. 28.

In like manner, the veins are said to be devoid of irritability, because no irritability is evidenced on the application of various stimuli, mechanical or chemical, except such as may be the effect of pain or fear, or of the action of chemical agents on the texture of the vessels, or their contents. It is true, that the terminations of the venæ cavæ, (whose structure is obviously muscular, as derived from the auricle,) claim an exception from this general representation. 4th, Irritability.

The veins are likewise possessed of a peculiar property, termed insensible contractility, or tonic power; the influence of which is particularly instrumental in aiding capillary circulation. 5th, Insensible contractility.

It would be foreign from the subject of this Essay, to enter largely into the pathology of the venous system; it may, however, be remarked, that veins, like all other living structures, are subject to disease. The complexion of the respective diseases of arteries and veins, is, like their structure, distinguished by marked peculiarities. The veins take on inflammation much more readily than the arteries, whether from surgical operations, or diseased action. But the promptitude with which a wound caused by phlebotomy is agglutinated and cicatrized, materially distinguishes it from a similar incision of an artery; and herein we behold a most providential result; since, if this were not the case, that operation, which is, as it were, the surgeon's right hand in the treatment of many diseases, would be detrimental or destructive, and consequently impracticable. Of the pathology of the veins.

Phlebitis. There are also severe, and even fatal, consequences resulting from undue inflammatory action in the veins; this is fully exemplified in the disease termed phlebitis. In such a case, the vessel is seized with inflammation, which spreads with considerable rapidity along its internal surface; and sometimes extends from the point, where the affection first commenced, even to the heart itself, bringing on a train of formidable symptoms. But the formation of pus, within the cavity of the vessel, is the principal source of danger; and sometimes, even an effusion of coagulating lymph takes place, plugging up the vein, and ultimately producing its conversion into a solid chord.

Varices. The affections termed varices, consisting of a tortuous, knotty, dilatation of the veins, either with thickening, or extenuation of their coats, occurring as they do, for the most part, in superficial and depending situations, must necessarily interfere with the functions of their valves, which are, no doubt, frequently in a diseased condition; and it is probable, the derangement they must, under such circumstances, sustain, operates as an impediment to the flow of venous blood; thereby causing a great aggravation of the disease itself.

Vital properties of veins. That veins are endued with a large amount of vitality, is manifest from a single example. Observe a case of phagedenic ulceration, or hospital gangrene, and remark how the blood vessels will be exposed, and, as it were, dissected, by the terrific ravages inflicted on the surrounding substance;

but, in the midst of this wide spreading work of destruction, they maintain their integrity; and it is not until an advanced stage of the disease, that hæmorrhages supervene.

Having already traced the formation of the sanguiferous system, from the lowest to the highest orders of animal life, I shall now proceed to the consideration of it, in the embryotic state of existence.

Developement of the venous system in embryotic existence.

The formation and gradual developement of the embryo, is a subject invested with the deepest interest, and has received a large share of the attention of the most distinguished physiologists. It was supposed, at no very remote period, that the nervous system was the first formed; but recent discoveries have proved, that the vascular system has the precedence. According to some French philosophers, the veins are formed first; next, the heart; and lastly, the arteries: while, an Italian physiologist has maintained, that the arteries are the first to appear.

The ovum, when first expelled from the Graafian vesicle in the ovary, and conveyed by the Fallopian tube into the uterus, occupies the lowest grade of human existence; since, in structure, it closely resembles the infusoria, hydatids, and polypi, and other animals in the lowest ranks of the creation; and, as it gradually advances in the stages of its developement, it begins to bear some resemblance to the yolk of a bird's egg.

Nothing is at first perceptible but a small vesicle,

or membranous bag, filled with a transparent albuminous fluid; from which the intestinal canal is supposed to have its first origin, and which corresponds with what is called the yolk-bag in ornithology; whereas, in human anatomy, it has received the name of *vesicula umbilicalis*.

It is difficult to determine with precision, which part of the vascular system is first developed; but there is little doubt, from the analogy which exists between the yolk-bag in birds, and the *vesicula umbilicalis* in the human embryo, that the vein of the vesicula is the first to be developed. This, from its connexion with the vessels of the mesentery, is called *vena omphalo-mesenterica*. This vessel, in its rudimentary state, in the chick, possesses no proper coat, but consists merely of canals, excavated out of the substance of a membrane, formed by some hollow globules, or a series of vesicles, which increase in number, and, approaching nearer and nearer, at last coalesce and form a vessel, and are soon filled with blood, in lieu of the transparent fluid, which they previously contained.

The walls, forming these canals, gradually become consolidated, and the work of developement progressively advances. As above stated, the *vena omphalo-mesenterica*, joins the mesenteric vein, which is the primary branch of the *vena porta*. This vein, which is at this period the principal trunk of the venous system, ascends perpendicularly to the point, where the heart is ultimately developed, and forms a slight ampulla, which cor-

responds with the auricle. From this dilatation the aorta proceeds, and distributes the blood to the different parts of the body, the corresponding veins being formed about the same time; at this period also, the *arteria omphalo-mesenterica* is produced. The umbilical vessels seem to be developed in the same order as the *vasa omphalo-mesenterica*, which they appear to supplant; the vein first, the artery afterwards, is superseded in its functions by these successive developements in the fœtus. The umbilical vein then becomes connected with the vena portæ, which previously passed up behind the liver, and now becomes connected with it, and both together ramify in its substance.

The heart first makes its appearance in the shape of a slight annulus, the left ventricle being the part first recognized; above which the aorta appears in the form of a slight dilatation, which soon approaches, and becomes connected and condensed. The right ventricle has the appearance of a small tubercle, extending towards the apex of the heart, which primarily consists only of two cavities, an auricle and a ventricle; each of these, in the progress of organization, is divided into two by a septum; which at first is in both instances incomplete; and even at birth there is a communication between the auricles, by means of an aperture in the *septum auricularum*, termed *foramen ovale;* which, however, is speedily closed after birth.

Finally, the pulmonary artery presents itself in the shape of a distinct trunk, communicating with

the arch of the aorta, through the medium of a short tube, the *ductus arteriosus*, which opens into that vessel opposite the origin of the left subclavian artery. The pulmonary artery, having thus communicated with the aorta, divides into two branches, one for each lung. To continue the account of these embryotic developements, the spinal marrow appears before the brain; and the latter before the cerebellum; accordingly, it is found, that the vessels of the spinal chord shew themselves before those of the brain, and the vessels of the brain are manifest before those of the cerebellum.

Peculiarities of the fœtal circulation.

The venous system is, at birth, perfect in all particulars, and fully organized; but there are a few striking peculiarities existing previously to that moment, which it may be well briefly to allude to. The umbilical vein, which supplies the fœtus with blood, commences by innumerable radicles in the placenta, enters the umbilical aperture, proceeds to the horizontal fissure of the liver, inclosed between the layers of the falciform ligament. Traversing the horizontal fissure, it gives branches, on either side, to the right and left lobes of the liver, especially the left, which is at this period considerably the largest.

Arriving at the *transverse fissure*, it divides into two branches; one branch joining the *vena portæ;* and the other, the *ductus venosus*, joins the hepatic veins at the point, where they are about to empty themselves into the *vena cava*. This blood is then conveyed by the *vena cava inferior* to the right

auricle, whence it passes direct into the left auricle through the *foramen ovale*, which is furnished with a semilunar valvular flap, so constructed as to allow a free passage for the blood into the left auricle; whence it passes into the left ventricle, which propels it into the aorta, the ascending branches of which carry it to the head and upper extremities, but little passing into the descending aorta : from these parts it is returned by the corresponding veins to the right auricle, through which it passes, without admixture with the blood of the inferior cava, into the right ventricle ; from which it is again propelled into the pulmonary artery ; but on arriving at the *ductus arteriosus*, the greater part of it passes through it into the descending aorta, to be distributed to the lower regions ; for the pulmonary arteries, in the collapsed state of the fœtal lungs, are incapable of conveying it away, and merely take such a portion as will suffice to make and keep pervious those canals, which are destined shortly to undergo a large amount of distension.

The blood received by the descending aorta is partly distributed to the abdominal viscera and lower extremities ; but is chiefly conveyed by the hypogastric or umbilical arteries back to the placenta. Thus the fœtal heart, although composed of two auricles, and two ventricles, virtually performs merely the functions of a single or undivided heart; since both ventricles conspire simultaneously in propelling the same column of blood, namely, that

of the aorta; and thus enabling the heart in this feeble state to act with greater power.

Phenomena of the sanguiferous system at birth.

The phenomena which supervene at birth in reference to the sanguiferous system, are principally as follow: the connexion of the fœtus, by means of the umbilical chord, with the parent, is dissevered; thus precipitating it, as it were, from its parasitic and dependent condition, to a separate and independent one. Being thrown upon its own resources, it is necessary that the process for renovating its blood should be brought into immediate operation. The respiratory muscles are now, for the first time, excited to action; the chest is expanded; the diaphragm descends; all the lungs become inflated, elastic, and crepitous; the ramifications of the pulmonary arteries, over the distended air cells, now become suddenly pervious; a vacuum is created, and the blood rushes into the newly opened channel, as fast as it is supplied by the right ventricle. The vital stream, thus plentifully conveyed to the lungs, is carried back to the left auricle, which now in its turn becomes distended; there is, at this time, a tendency in the blood to regurgitate from the left to the right auricle, contrary to its former course; but this is prevented by a valvular apparatus, that of the *foramen ovale*, which soon becomes firmly attached to the *septum*.

By the distension of the pulmonary artery, its distance from the aorta is increased; the *ductus arteriosus* thus put upon the stretch, is partially closed,

and soon becomes totally obliterated. The extinction of the *ductus venosus* may be explained in the same way: when the diaphragm descends, it carries the liver with it; the distance between it and the heart is thereby augmented, and the *canalis venosus* is thus pressed upon and made tense. There being now no further use for the umbilical vessels, they contract, and are converted into fibrous chords, in which capacity they continue to render important service as ligaments.

Peculiarities of the venous system in the fœtus.

Although the veins are, doubtless, fully organized in the fœtus, they are nevertheless of smaller dimensions during that period of life, as well as during growth, than the arteries; which is palpably the reverse of what takes place in the condition of these vessels in the adult; this may fairly be attributed to the fact, that the various organs of the body retain for their nutrition and developement a much larger quantity of blood during growth, than in adult life; there is consequently a smaller quantity of that fluid to be returned by the veins. Nevertheless, the pulmonary artery, which, from its connection with the system of dark blood, is termed *vena arteriosa;* and the right side of the heart; and that portion of the vena cava inferior, which intervenes between the liver and the heart; are all proportionably more fully developed in fœtu, than the rest of the venous system. But this may be attributed to an anatomical fact, application only to the fœtus; namely, that they are the immediate recipients of the blood, transmitted from the mother to

the child, through the medium of the umbilical vein.

Varices absent in infancy, present in age, why?

The absence of varices during infantile life, may be ascribed to the comparative vivacity of the circulation at that period, to the diminished capacity of the veins, and the increased ratio of their resistance. In adult life, when the organs have attained their full growth, and when all the parts have arrived at maturity, the diameter of the veins is sensibly increased, they become much more prominent, and seem to contain more blood. But the greatest and most important changes await old age; for at this stage of life, their enlargement is more decidedly perceptible, and the tenuity of their parietes becomes evident: these causes, added to their diminished energy, and the condition of the circulation, (which partakes of the universal languor and feebleness of the whole system,) are the principal causes of varicose disease, the bane of advanced life.

Origin of the veins.

The veins take their origin from the ultimate ramifications of the arteries. These minute vessels, which in incalculable numbers pervade every part of our frame, are so fine as generally to escape observation; but so numerous are they and universal, that if the skin be merely punctured with the finest instrument, blood is seen to ooze from the wound. The body may, therefore, be regarded as one great vascular mass; every atom of which may be said to be a laboratory for the conversion of red into black blood; for we know that every part of the

system, largely consumes the vital element, deteriorates the arterial blood, and constantly requires a new supply of the purified and aerated fluid.

The communications of the capillary veins, with the capillary arteries, are beautifully seen, with the aid of optical instruments, in the transparent membranes of frogs and fishes. But although we know that veins and arteries do communicate, it would be difficult to assign the limits of each, or to decide with precision where the one terminates, and the other begins.

The capillary system is either general or pulmonary.

With respect to the veins, the capillary system may be classified into general, and pulmonary; the former is the more extensive, and involves the whole of the body; here the residual blood is taken up by the veins, and conveyed to the right side of the heart, completing the great or aortic circle; the latter or lesser system, is comprised in the parenchyma of the lungs, from which the renovated blood flows to the left side of the heart, through the pulmonary veins, completing the pulmonic circle. Speaking generally, the superior cava receives the blood taken up by the venous radicles of the upper half of the body; while the inferior receives from its tributaries, the blood disseminated in the lower half.

As the origin of the veins is every where essentially the same, proceeding from the general capillary system, it would be superfluous to particularize every organ from which they spring. I purpose, therefore, to advert only to such as present pecu-

liarities, as, for instance, the cerebro-spinal, and abdominal veins.

Peculiarities of the veins of the brain.

The blood is conveyed from the substance of the brain, by vessels of remarkable delicacy, as well as from the *dura mater* and in part from the cranial bones, into a set of channels, (the calibre of which is, for the most part, triangular,) termed sinuses. These vessels are essentially veins, differing only from the rest of the system, in structure and arrangement; they are interposed between the cerebral veins, and internal jugular, being inclosed between the lamellæ of the dura mater, which here is substituted for, and performs the office of, both external and middle coat.

They are without the external and middle coats.

Although deprived of the external and middle coats, possessed by other veins, they are, in lieu thereof, invested with a dense, fibrous, inelastic covering, furnished by the dura mater; the inner tunic being derived from the common membrane of the venous system, which is continued into them from the internal jugular veins, into which the sinuses eventually empty their contents.

Some of these sinuses, and the superior longitudinal in particular, have small, white, fibrous bands stretched obliquely across them. These have a remote resemblance to the *valves* of the veins; and as they are formed especially in the larger sinuses, they doubtless serve to prevent too great distension.

The modo in which the veins enter the

The manner in which the veins, laden with blood from the brain, open into these sinuses, is deserving

of special notice, as affording an instance of manifest and merciful design. They run obliquely forwards for a considerable distance, between the coats of the sinus, in a direction contrary to the current of the blood, some for an inch, others for less, before they open into it; and just before their termination, they turn slightly inwards. sinuses, is a provision of God's wisdom and goodness.

The purpose of this arrangement appears to be, to prevent the reflux of blood into the cerebral veins; for although regurgitation may take place into the sinus, the direction of the venous orifices does not permit any farther reflux of the blood. The consequence of any varicose dilatation of them would be fatal; but such an accident is providentially and effectually guarded against, by the unyielding nature of the dura mater, and by those transverse and oblique bands, which are found in their cavity. Those bands are fixed in a certain position, between the layers of the dura mater; and no motion is allowed them, because from the immoveable construction of the cranial cavity, none is requisite, and they act as stoppages and preventives of mischief.

The blood is probably urged into these sinuses, from the cerebral veins, by the perpetual oscillatory movement of the brain; and gravity seems to have considerable influence in conducting it onwards to the heart: the phenomena occasioned by an inverted position of the head, furnish a sufficient warranty for such an inference.

The spinal like the cerebral veins, have their Peculiarities of the spinal veins.

peculiarities, which distinguish them from the venous system in general. The blood is received, from the substance of the spinal chord, by a network of veins on both its surfaces, within the tube of the dura mater. These do not increase in magnitude as they approach the foramen magnum, near which they unite into two or three small trunks, terminating in the inferior cerebellar veins, or petrosal sinuses. The fact of their maintaining nearly the same size (for they are somewhat larger in the lumbar region) along the whole of the medulla spinalis, arises from the blood being carried from them into the great spinal veins, (by branches which accompany the nerves towards the intervertebral foramina,) instead of ascending or descending. These veins also receive the blood from those, which emerge from the foramina in the posterior surfaces of the bodies of the vertebræ.

The large spinal veins are two in number, extending the whole length of the spine, situated in its interior, opposite the junction of the bodies with the processes of the vertebræ. At each of the intervertebral foramina, they are constricted, having consequently intermediate dilatations, presenting the appearance of a series of links; each of which seems, as it were, to be an independent trunk; being occasionally isolated entirely, from all connexion with the link situated either above or below, receiving the blood, on the one hand, (as explained above,) and transmitting it, on the other, into the branches of communication through the

Link-like appearances.

intervertebral foramina; there is, therefore, no appearance of any ascending or descending current. The blood is carried from these by the communicating branches, into the lumbar, intercostal, and vertebral veins: which also receive the contents of a venous plexus lodged within the arches of the vertebræ, made up of such intricate interlacements of veins, as almost entirely to cover the dura mater. On considering the general position of these vessels, the blood appears to pursue a horizontal course; or rather, a succession of such courses, one above the other, from behind forwards, into the general circulation.

Interlacement of those veins.

The vena portæ may be said to form of itself a distinct system, from the moment of birth; whilst previously to that period, it forms only a part of the general fœtal circulation. There are several singularities in connexion with it, which claim for it a separate notice; but much that is desirable to be known respecting it, is involved in obscurity. Its importance is declared by the fact, that it is found in nearly all animals. Its external tunic is more dense and strong, than in the majority of veins, and its lining membrane forms *no valves*. Its hepatic portion receives an additional envelope from the capsule of Glisson, which accompanies its ramifications in the liver, being more intimately attached to that viscus than to the veins themselves. It is owing to this that on a section of the liver being made, the ramifications of the vena

Of the portal circulation.

Absence of valves.

portæ are readily detected, by the expanded state of their orifices.

The vena portæ arises from that division of the abdominal capillary system, connected with the gastric apparatus, commencing between the coats of the stomach, intestines, &c. and terminating by inosculation with the capillaries of the hepatic veins. The blood, therefore, is conveyed from all the chylopoietic viscera by numerous veins, which unite to form one large trunk, the vena portæ; which after a course of about two or three inches, arrives at the transverse fissure of the liver, (where it divides into a right and left branch,) and then enters the corresponding lobes, spreading out into branches, and ramifying in their structure. But the veins from the kidneys, and the pelvic viscera, are totally excluded from any communication with this vein, which preserves its integrity and independence throughout its course. The blood, distributed by these vessels in the liver, is collected again, and carried into the vena cava inferior, by the hepatic veins.

The origin of the veins is in the capillary system.

Thus then it has been made to appear, that the veins take their origin in the general capillary system; of which nothing can be stated positively, as the result of observation and experiment, by reason of their extreme tenuity; but it is probable, that as they are so intimately interwoven with the structure of organs, they partake, in some measure, of their respective textures.

On issuing from the general capillary system, the veins, which take the same course as the arteries, are arranged in juxta-position with them, being sometimes closely connected with them, and sometimes separated only by a slight interval; but, in both cases, union is maintained between them by cellular tissue, more or less reticulated. Thus they traverse, in company, the interstices of muscles, the interlobular spaces of the glandular system, or the layers of investing membranes, to arrive at their organs respectively.

Superficial veins.

The superficial veins, for the most part, take a distinct route, unaccompanied by arteries, and form a very numerous class; these may be seen beneath the integuments, particularly in subjects of a scrofulous taint; in whom considerable trunks are visible, and a proportionate number of smaller ramifications. These veins, having run their subcutaneous course, dip down to those more deeply seated, into which they pour their contents. But it is not in superficial situations alone, that veins pursue a separate course; for there are instances of a like nature in the cavities. The arteries of the brain enter its substance from below; the veins, on the contrary, tend towards its upper surface. In the chest we find the vena azygos, without any artery answering to its course: and, in the abdomen, the blood is poured by the vena portæ, and the hepatic arteries, into the liver; but the veins emerge from it in a contrary direction, to join the inferior cava.

General course of the veins.

With respect to the general course of the veins, they may be said to tend from the circumference, if I may so express myself, towards the centre. They are more direct in their course than the arteries, which make numerous turns; this undeviating direction much facilitates the flow of blood in the veins; whilst the arterial current, being driven into its tubes by the powerful agency of the heart, experiences little retardation from their tortuosity, which appears to be indispensable, to admit of the varied and extensive movements of the body, without injury to their structure, or hindrance to the circulation. Whereas there is a different provision for the safety of the venous coats; their flexibility protects them from lesion, and permits unrestrained motion; whilst their plexuses of anastomoses secure the continuance of the current, under topical pressure, and partial stoppage of the stream in particular veins.

Final termination of the veins.

The veins, in their progress, gradually increase in size, as they diminish in number; till, by the progressive union of branches and trunks, the venous current is at length concentrated in two large canals, terminating in the right auricle, and continuing incessantly to pour the blood, collected from every particle in the body, into that cavity. The blood from the substance of the heart itself is emptied into the same cavity by the coronary vein, the orifice of which is guarded (as before observed) by a *valve*, to prevent the re-entrance of the blood into it, during the contraction of the auricle.

Of the capacity of the veins.

It will be evident, from what has been said, that the capacity of the venous system is much more considerable, than that of the arterial. This may be easily verified, by comparing a given vein with its corresponding artery, or by referring to the venous system collectively. Independently of the subcutaneous set of veins, and the greater capacity of veins in general, many of the deeply-seated arteries of the extremities have two *venæ comites*.

The same observation will, in due measure and degree, apply to the right and left sides of the heart: the same remark may also be made in reference to the comparative dimensions of the pulmonary arteries and veins.

The blood, having been rapidly conveyed from the right side of the heart, through the pulmonary artery, into the lungs; that blood is slowly returned to the left side of the heart, by the four pulmonary veins, in order to be again driven through the aortic tubes. Thus we have the same principle, throughout the whole sanguiferous system; namely, in the arterial, less capacity, greater strength, and consequently increased rapidity of motion; in the venous, on the contrary, we have greater capacity, less strength, and slowness of motion. The reason why the veins exceed the arteries in diameter, is resolvable into the fact, that the propelling power of the left ventricle is very great; and, by this agency, the blood is forcibly urged through the aortic ramifications, to their very extremities; but, as the veins are without this *vis a tergo*, their current

Striking differences observable in the arterial and venous system.

must be more tardy: therefore, in order to accomplish the return of the blood, greater capacity is indispensable. The joint area of the two venæ cavæ, is much more considerable than that of the pulmonary artery alone: hence, at first view, it might excite some surprise, by what means so great a mass of blood, as that poured into the auricle by the former vessels, could be carried off and conveyed away by a vessel considerably smaller; but the difficulty is accounted for, when we recollect the great power of the organ which propels the stream.

Anastomoses or communications of the veins with each other.

Much irregularity is observed, in the manner in which veins unite with one another, in their passage towards the centre of the circulation. The majority of them take an oblique direction with regard to the trunk, with which they are about to unite; that is, they form acute angles, as affording the greatest possible facility to the progress of the current; or rather, as creating the least impediment to the flow of blood in the trunk, into which they are about to open: for, if the branches were to pour their contents into a trunk, in a direction contrary to the current in that vessel, or at right angles with it, a hindrance to that current would necessarily be the consequence. The course of the spermatic veins, in relation to the vena cava, affords an example of such an union at an acute angle.

The observation is not intended to be universal; for many veins are joined at right angles by their twigs, for instance, the intercostal, lumbar, and

renal veins. There are, likewise, examples wherein branches pursue such a course in reference to their trunk, as to form an obtuse angle with it. The relations of the cerebral veins with regard to the superior longitudinal sinus, may be cited as examples of this deviation from the usual mode of conjunction; but in all these instances special reasons are to be discovered, and appropriate ends to be accomplished.

The anastomosis of veins may be regarded as one of those important provisions of Divine wisdom and goodness, in the production of which, the all-wise Creator has evinced a special superintendence, lest accidental causes should hasten or precipitate our destruction, before the arrival of the period of natural decay; or of those internal causes, which are inseparably interwoven with the conditions of our mortal existence.

The anastomosis of the veins a provision of Divine mercy.

By anastomosis (in the anatomical acceptation of the word) we understand, not that conjunction of two or more branches, so as to form one trunk, or of two trunks to form a larger one, which have been before spoken of, but, that intercourse which takes place between different veins, through the media of cross branches. Anastomosis occurs with greater frequency in the venous, than in the arterial system; because from the structure of the latter, their remoteness from the surface, and the velocity of their current, such an intercurrence between the trunks, is less needful. A very free inosculation, however, does exist between the arterial ramifi-

Anastomosis, what?

cations; and on this wise arrangement, are based some of the noblest achievements of the surgical art in the present day. Recollecting this circumstance, the modern surgeon fearlessly and successfully undertakes operations, which, at no very remote period, would have been regarded as inevitably destructive to the individual.

Three great distinctions observable in the anastomosing process.

The venous anastomosing branches are subject to much irregularity, in number, size, and direction. Three great distinctions, however, may be observed in this process of uniting veins by anastomosis. The first mode is accomplished by means of cross branches, which are either oblique or transverse in their direction; as may be seen in the subcutaneous veins of the extremities, and likewise between the venæ comites, which frequently communicate with each other, by branches thrown across their artery. The second method is executed by direct inosculation, or by branches given off, which, by the union of their extremities, form arches; this mode receives ample illustration in the folds of the mesentery. The third manner in which anastomosis is effected, is by indiscriminate interlacement, in which the branches observe no particular arrangement, or relation to each other, but divide and reunite indifferently, forming a network. The branches constituting the internal iliac vein, form several of these plexuses; which, from their locality in reference to the pelvic viscera, have received the respective names of vesical, hæmorrhoidal, &c. The veins of the spinal canal afford an extensive

and beautiful illustration of this sort of anastomosis: intricate plexuses are found throughout its extent, receiving the blood from the chord, its membranes, and the bones; communicating with the cerebellar, vertebral, intercostal, azygos, lumbar, and pelvic veins, as well as with those from the cervical and dorsal muscles.

Anastomoses of the vena azygos.

The vena azygos effects an important communication by anastomosis, between the inferior and superior venæ cavæ: this vein has its commencement either from the inferior cava, below the diaphragm, or from the renal, or a lumbar vein; it proceeds into the thorax, along the front of the vertebral column, and at length terminates in the superior cava, thus establishing a direct intercourse between those great trunks; an intercourse of great importance, when we consider, that in the event of an obstruction in the inferior cava, above its point of communication with the azygos, the supervening pressure of a largely increased quantity of blood would increase the capacity of that vessel sufficiently to enable it to carry on the circulation.

Independently of the anastomosis existing between the branches of superficial and deep orders of veins individually, they likewise freely communicate with each other, by means of branches, which pass to and from, between the muscles. The median vein of the fore-arm is an illustration of such an intercourse; on approaching the elbow, it divides into three branches, one of which unites with the basilic vein, another with the cephalic, while the

Farther illustration of Divine mercy.

third dips down, and joins the deep veins. This communication between the superficial and deep-seated veins, is evidently the work of infinite Goodness and consummate Wisdom; for, by its interposition, external local pressure, as I have before observed, cannot obstruct the circulation; since, if one vein be subject to impediment, the blood flows with equal freedom by another; and hence it is, that the pressure of bandages is not only tolerable, but beneficial: for, although the degree of compression be such as to hinder the subcutaneous circulation, it nevertheless proceeds uninterruptedly through those vessels, whose deeper situation has placed them beyond the influence of external ligatures or bandages.

It has fallen under my own observation, in the dead subject, that the femoral vein has become obliterated, nearly through the whole of its course, extending downwards even into the popliteal and crural veins, by a fibrinous deposit in their cavity, and rendering them totally impervious to fluid. Now, in this case, the circulation must have been carried on, in a great measure, by the superficial veins, and, in particular, by the *vena saphena major;* which, commencing on the foot, receives many tributaries from the leg and thigh during its ascent, and finally terminates in the femoral vein, in the femoro-inguinal region; the obstruction, in the instance alluded to, not having extended so high.

Absence of anastomosis from the veins in the

That freedom of anastomosis, which characterizes the venous system in general, is not observed

in the cerebral sinuses; for, so securely are they lodged in their bony cavity, that they are not liable to obstruction from extraneous causes; and consequently, the provision against such obstructions are not wanted. The same may, likewise, be said of the hepatic portion of the vena portæ; for the firm and resisting structure of the liver, protects it from mechanical influence; but the gastric portion of that vein, being subject to the same conditions as other veins, like them enjoys a free communication by anastomosis. This communication is commensurate with the nature and degree of the impediment opposed to the circulating current; and it antagonizes, both against the impeding influence of gravitation, and the power of external agents.

cerebral sinuses, and why?

Anastomosis is rare in the large trunks, when compared with that existing between the smaller; and the ratio rapidly increases as we approach the capillary system, where it is unbounded, and scarcely comprehensible or calculable by our senses. In short, it constitutes one great and universal plexus, extending from head to foot: our venous system may be regarded as one universal anastomosis, one great circuit of interwoven and inosculating vessels.

The fact of the circulation of the blood is so fully established, that it would be superfluous to enter upon any general discussions, or to repeat what has been so ably substantiated by physiologists, or to insist upon what has been universally admitted and

Of the circulation of the blood.

appreciated. That the blood flows through the veins, from the ultimate capillaries to the heart, is a fact which may be said to be proved by the *valves* alone, and that too so conclusively, as to make additional evidence unnecessary.

The vis motrix of the blood.

But to explain as fully and satisfactorily, *how* it flows, by what influence its motion is maintained, without cessation and without fatigue, in all the conditions or positions of our frame; by what agency it continues to move, to us almost unconsciously, under all the alternations of activity and repose, through our waking and our sleeping moments, with the same undeviating regularity, is a point most interesting in itself, but most difficult to account for, and is to be reckoned as one of the many mysterious facts which the Creator has placed beyond the reach of man's utmost assiduity.

Harvey's doctrine.

It was Harvey's doctrine, that the heart is the sole agent, the vis motrix, in producing these phenomena; but important as are the functions of that viscus, is it certain that other agents are concerned. In some classes of animals, the circulation is wrought without the aid of such an organ. Others have maintained, that the blood, being a vital fluid, cannot remain inactive or simply passive, during its circulation; but that it contributes materially to its own motion, by the aid of its vitality, an opinion, which may be said to accord with the declaration in Scripture[a], " the blood is the life of

[a] Quinimo ex vario ipsius, sc. sanguinis, motu in celeritate,

all flesh." (Levit. xvii. 14. also Gen. ix. 4.) Others have entertained the notion, that hydraulic science may be successfully resorted to, to account for the circulatory motion: it may serve to illustrate, but not to explain it.

Physical principles insufficient to explain the circulation.

To apply mechanical principles, for the explanation of vital functions; to compare the mechanism, which is the result of man's ingenuity, with the fabric of the living body; to endeavour to assign reasons for the functional energies of the latter, upon principles which belong to the former; is, to attempt to make the methods of Omniscience subject to the *modulus* of human understanding: for life, that heaven-born principle of existence, which, though intimately associated with the animal machinery, God alone can impart, is dependent upon the invisible power of Providence, and the secret will of God. The very fact that hydraulic and mechanical principles have failed to account for the blood's motion, in its reservoirs and canals, proves, that physical principles alone are altogether insufficient to enable us to find out the causes of man's existence. Vital influences must be referred to, to explain the sacred gift of God, the momentous trust, of life. We every where see inert bodies gravitating one to another, and exerting reciprocal attraction: living bodies gravitate also, but they

The principle of life.

aut tarditate, vehementiâ aut debilitate, et cæteris, eum et irritantis injuriam, et foventis commodum persentiscere manifestum est; ideoque concludimus, sanguinem per se vivere et nutriri. *Gul. Harveii Op.* tom. ii. Exercitatio 52.

feel and experience, moreover, a motion which they owe to the infused or superinduced principles of life; a power which, in the words of Revelation, may be said to have been breathed into man's nostrils, and to constitute the *vis insita* of the human body. It is the same divine principle of vitality, which causes the valves of the veins to open and shut, to act and operate; and we have seen how admirably and perfectly they are calculated to discharge the function for which they are intended. What would be the consequence of the absence of the valvular apparatus? The veins would have to counteract the force of a large column of blood, and the difficulty would be increased tenfold by the influence of gravitation; which meeting with no opposition to its tendency downwards, would operate with unrestrained force, and by congestion oppress the vessels below. The weight of a large quantity of blood above, would certainly resist and oppose the progress of that which was striving to ascend; the natural consequence would be, a stoppage, if not a reflux, in the circulation; or such a distension in the venous parietes, as to produce rupture, or some other organic lesion. As a protection against such fatal results, we find *valves* more numerous in the subcutaneous veins, than in those which are seated between the muscles, and other resisting structures; and in the veins of depending parts, (in which the blood has to ascend towards the heart, against its gravity,) than in those where no such resistance exists. *The valves*, in fact, divide a vein into a

Physiology of the valves of the veins.

Sustaining power of the valves.

number of compartments, and in this way separate the column of blood it contains, into parts or portions; and hence it follows that the resistance of the walls of the vein is increased, in the same proportion, as the distending power of its contents is diminished. But the fact admits of illustration by diagram or drawing. This, which is copied from Dr. Roget's treatise, represents the valves sustaining the blood, and preventing its reflux; the arrow shewing the direction of the ascending current.

But the valves, by sustaining the blood, do not only counteract its tendency to gravitate; but as a necessary consequence permit the uninterrupted exercise of all those agencies which conspire (with an union of purpose truly astonishing) to effect the end intended, namely, the return of the residual blood, now contaminated in the tissues and organs of the body, to be again elaborated into vital purity. Again, in the exercise of certain influences, such as muscular action, &c. the valves play no unimportant part: for were there none of them in the veins, muscular exertions and bodily movements would be as liable to propel the blood in one direction, as in another; but the timely intervention of valvular aid is so effectual, as to prevent any retrograde course of the blood; for meeting (in the valves) with an obstacle to any refluent tendency, the blood

Cooperation of the valves with other agencies.

With muscular agency.

immediately pursues that which offers a free passage onwards.

Such then, and so many, are the evidences of special purpose and design, manifested in the multifarious mechanisms of the venous system, and particularly in the valves of the venous tubes; (for it is to the consideration of these I am confined by the terms of the thesis proposed.) But if it were permitted me to extend the range of the argument to the valves of the heart and the arterial circulation, there would be found, if possible, still more sublime developements of creative omnipotence and providential mercy. Upon the sight of such examples of wisdom, power, and goodness, who can forbear the application of the Apostle's words, "O, the depth of the riches, both of the wisdom and knowledge of God[b]!"

The valves of the heart do not belong to this argument.

All nature abounds with physical proofs of the Divine attributes.

True it is, that every science may be said to teem with proofs of the like nature; there is no department of physical knowledge without them. The Patriarch Job has sent us for such instruction to the rainbow, the storm, and the thunder-cloud; to the planetary system, and the still vaster firmament of the sun, and the fixed stars; to the terrors of the deep, and the riches of the bowels of the earth; to the beauties of the feathered tribe, and the courage of the war-horse; to the desolation of the desert, the influences of stormy and freezing skies, and to that last refuge and receptacle of our

[b] Rom. xi. 33.

mortal nature, the grave. By such an accumulation of instances, we are led to admire and adore the manifold wisdom of God, ἡ πολυποίκιλος σοφία τοῦ Θεοῦ[b], and to confess, that it was He *who hath made the earth by his power, established the world by his wisdom, and has stretched out the heaven by his understanding*[c].

Nothing under the vast canopy of heaven can be looked upon, which does not attest the omnipotence and omniscience of the Almighty. Whether we soar above the ethereal realms, and contemplate the bright luminaries which throw their rays throughout the vast expanse; or whether we penetrate the recesses of the earth, and analyze its stony and metallic wonders; whether we scale the mountain, or dive into the flood; whether we explore the lands which are scorched by the vertical sun, or constricted by polar frost; stretched out into the dreary waste, or darkened by the gloomy forest; smiling with the verdant pasture, or the golden harvest; or, lastly, whether with microscopic aid we more closely fasten our attention upon animate or inanimate matter; by whatever path we pursue our investigations, we shall be always brought to the acknowledgment that *the Lord is wonderful in counsel, and excellent in working*[d], *that his works are manifold, and that in wisdom hath he made them all, and that the earth is full of his riches*[e].

[b] Eph. iii. 10. [c] Jerem. li. 15. [d] Isaiah xxviii. 29.
[e] Psalm civ. 24.

But the human body teaches these lessons most impressively.

But the same infinitely wise, good, and powerful Being, who built the stupendous fabrics of the planetary masses, and bade them pursue their appointed courses, and who upholds and continues their vast gyrations, has exhibited his attributes in their most impressive strength and instructive variety in the formation of man's body. *Thus saith the Lord, the Holy One of Israel, I have made the earth, and created man upon it*[f]. The earth is full of the glory of God but "man created upon it" supplies the most diversified and demonstrative evidences of his might and mercy.

If we trace him to his fœtal origin, we find him taking his rise from an atom of imperceptible minuteness, in which there are no traces of his subsequent condition, but which (by one or more of those many mysterious processes which are continually going on in every structure, and every function of the body) progressively becomes allied to his species, and at last is made man. We see organs formed, and watch their gradual developement; and at length the period arrives, when all being matured, unite their energies with each other, acquire the full possession of their powers, and are fitted to perform the various functions of life. In order to maintain the requisite condition for the proper and continued action of those organs, a process of perpetual renovation is carried on, by renewing the materials of which their fabric is composed, which thus undergo a constant muta-

[f] Isaiah xlv. 12.

tion, the old particles being removed, and the new ones deposited in their place; the repetition of the same circle of actions is thus carried on in such order, that the most perfect equilibrium is maintained between these additions and substractions of matter. But time, deranging the physical condition of the body, at length works a change in this process by disturbing that equilibrium, previously so strictly observed; the energies of the system decline, the reparative powers become insufficient to replace the waste in the substance of the body; which finally, in obedience to the universal law of "dust to dust[g]," pays the penalty pronounced upon man's nature at the Fall; In Adam all die, but in Christ shall all be made alive[h].

Testimonies to the brightness of the evidences which anatomy supplies to the glory of God's attributes.

Such is the divine mechanism, and chemistry, and vital energy, which, in the devout contemplations of many pious and profound philosophers, have made the body of man take precedence of all the organic structures of creation. "The contrivance of every animal, says Boyle[i], and especially of a human body, is so curious and exquisite, that it is almost impossible for any one, who has not seen a dissection well made, and anatomically considered,

[g] Gen. iii. 19.

[h] 1 Cor. xv. 22. See testimony of Natural Theology and Christianity by Thomas Gisborne, particularly in chap. vii. "on circumstances connected with the structure and nature of the human frame," and chap. ix. on "facts in common life which are evidently penal, yet accompanied with indications of mercy."

[i] See Boyle's Treatise "On the high veneration man's intellect owes to God," near the beginning.

to conceive how much excellent workmanship is displayed in that admirable engine." "For my part, (such is the emphatic declaration of Paley[k],) I take my stand in human anatomy." "Oh, adorable Creator! (was the pious exclamation of the admirable Bonnet,) with what wonderful art hast thou formed us! Though the heavens did not exist to proclaim thy glory; though there were no created beings upon earth but myself; my own body might suffice to convince me, that thou art a God of unlimited power, and infinite goodness[l]."

In the same spirit of devotion, another Christian physiologist exclaims, "What an immense multiplicity of machinery must be in action to enable us to breathe, to feel, to walk!" He then goes on to detail the particulars of this wonderful system, and to set forth "the hundreds of arteries to convey the blood to the remotest part of the system, and the hundreds of veins to bring it back again to its reservoir the heart." He then makes this observation, "that the whole of this vast mechanism must be in action, before we can walk across our apartments[m]."

Special objects of the Warneford Essay.

But the enlightened Christian philanthropist and philosopher, who has invited us to apply professional knowledge to the minute examination of the human body, for the fuller display of the Divine attributes, has not thought it enough, for the accomplishment of his design, that the essayist

[k] Natural Theology, chap. 18. at the beginning.

[l] Contemplation de la Nature, vol. i. p. 64.

[m] See Dick's Christian Philosopher, p. 369.

should, in these physiological contemplations, follow the examples of those, who (writing for general readers) confine their argument to large and popular surveys of structures and functions. It has been his expressed judgment, that examples of creative and providential power, wisdom, and goodness, should be sought for, not on the surface, but in the recesses of our mortal frame, that is, among those phenomena of man's bodily nature, which, though clear and certain, are deeply seated, and require in some instances the minutest anatomy to discover, and the exactest judgment to develope. Under this view of the subject, the wisdom of God may be said to be manifested in two different manners; it is sometimes seen in familiar objects, so that the most superficial observer may take notice of it; but there are many other things wherein the treasures of wisdom and knowledge lie deep, and must be deeply searched for, though they cannot be found out to perfection[m]. It is to these things that our attention has been directed by the Founder of this prize; it was from these things that he wished a twofold knowledge to be derived; a knowledge practical and professional, and a knowledge Scriptural and Christian; the first as the means, the last as the end; the first as subsidiary, the second as supreme. Upon the importance, or rather the necessity, of minute professional surveys of the depths and dark passages of the body, it will be needless to frame arguments, or cite authorities.

[m] Job xi. 7.

"*Quot curationes* (says Sandifort) *solius subtilioris anatomes cognitione nituntur*[n] !"

But it would be to derive but half the benefit which is attainable from the minutiæ of anatomy and physiology, if they were permitted to yield no other fruits than the verification of facts, or the settlement of practice. The respected friend and patron of our institution has sought, by the endowment of an annual Essay, to make exactness of research available for religious instruction; he has even contemplated an ulterior purpose, that of impressing a Christian character upon the religious instruction which is to be derived from the minuter investigations of human anatomy. For minute contrivances of Divine intelligence abound in the subjacent, as well as the superficial, parts of the human body, and each is a perfect example of surpassing wisdom, power, and goodness. But from among these countless instances of wise and beneficent adjustment, there is commonly some *one*, upon which the student of nature dwells with peculiar satisfaction; some one which for its beauty seems to be invested with irresistible attractions, or for its wonder, with overwhelming proofs of Divine power.

Minute anatomy.

He who has dedicated himself to the structure of the eye, would probably fix upon the minute apparatus of that organ of sense, as his great evidence and instance of the Divine perfections. The same disposition would probably be found to exist in

Some fix upon this, others upon that, instance of minute structure, for their favourite proof of Divine wisdom.

[n] See Sandifort's Oratio de officio Medici.

every one, who had directed his scientific researches to any particular organ or viscus, structure or function, part or particle, of the bodily frame. He would select the particular subject of his especial study as the grounds of his argument, and the materials of his demonstration, (it may be,) the theme of his praise, and the source of his gratitude. So too with him, who has dedicated his attention to the hydraulics of anatomy; he would be more particularly struck with the wonderful disposition and attachment of the valvular tissues. But who, whether he be a profound or a superficial observer, can look upon them, and remain insensible to the beauty as well as perfection of their mechanism. Even from the imperfect sketch here given of the valves, their structure, functions, and connection with the sanguiferous system, it must be evident to the most careless observer, that there is exalted wisdom in that provision, and paramount importance in those functions. But to the Christian physiologist they present one of the most unequivocal proofs that natural theology can supply, of the wisdom and goodness of God. We may ransack all nature for a superior demonstration; we may penetrate the interior of every part of man's economy, however complicated in its vascular or other provisions, without finding a brighter or more beautiful manifestation of creative power and providential care.

Paley's preference in respect of particular anatomical evidences.

True it is that Dr. Paley, in his concluding chapter, says, that, for his part, he should select for examples of mechanism, out of the copious cata-

logue which the body supplies, "the pivot on which the head turns, the ligament within the socket of the hip joint, the trochlear muscles of the eye, the epiglottis, the bandages which tie down the tendons of the wrist and instep, the slit or perforated muscles of the hands and feet, the knitting of the intestines to the mesentery, the course of the chyle into the blood, the constitution of the sexes." But though we do not find the *valves* of the veins enumerated in his list of provisions of surpassing excellence for the health and safety of man, it is not to be supposed that the author has left so manifest a purpose of God's wisdom and goodness unnoticed. That they have not received their proper amount of admiration, is unquestionable, because they have not been considered minutely in their relation to the ascending circulation. But what has been written cursorily on the subject of this hydraulic contrivance in the tenth chapter, shews, that the author's piety had been awakened by the valves of the veins. "The way to prevent the reflux of the fluid (the blood) is to fix valves, which, like flood-gates, may open a way to the stream in one direction, and shut up the passage against it in another . . . . . There is some variety in the construction of these valves, though all the valves in the body act nearly upon the same principle, and are destined to the same use . . . . . So long as the blood proceeds in its proper course, the membranes which compose the valve are pressed close to the side of the vessel, and

Paley on the valves of the veins.

occasion no impediment to the circulation; when the blood would regurgitate, they are raised from the side of the vessel, and, meeting in the middle of its cavity, shut up the channel. Can any one doubt of contrivance here? Or is it possible to shut our eyes against the proof of it? . . . . Whilst we see the use and necessity of this machinery, we can look to no other account of its origin, or formation, than the intending mind of the Creator."

Such are the theologian's general observations on valvular structures. To what he has so luminously written, I would subjoin the expression of my own admiration. The membrane of which they are formed, is expressly calculated to make their applicability perfect, and their use effectual. It is smooth and thin, but yet sufficiently strong to support the blood in the event of its regurgitation. It is shaped with such nicety, as to form, or to concur with others in forming, a perfect flood-gate, to direct, command, and control the current. It is distributed, wherever dangers, or liability to injury, demand such a provision, and is always of such a size and shape, and in such a position, as is best adapted to its functions *in situ*. It is always attached to the parietes of the vein in such a manner, as to be open towards the heart, when the blood is flowing naturally onwards; and these attachments to the parietes are so strong as to prevent retroversion. They are every moment engaged in their prospective functions, and are always prepared and ready to act, in case of any

Farther remarks on the valves.

disorder or irregularity in the forward flow of the blood. They need only be seen once, to be indelibly inscribed on the mind and memory, as a masterpiece of provisional construction; and when we reflect on the tenuity of these valves, we might perhaps be led to entertain the apprehension, lest those slender threads, by which the valves are held in their right places and positions, should break, and precipitate us from time to eternity, were we not conscious that this is but one of ten thousand liabilities of the same sort, to which the life of man is exposed, but which are all warded off by the never-ceasing energies of God's providential wisdom. For every one of these little instruments of Divine benevolence, frail as they appear to be, and delicate as they certainly are, continue their indefatigable activity on our behalf day after day, and year after year, with unremitting watchfulness, during the three or four score years of human life. The same provident and protecting Power, which keeps the celestial bodies in their orbits, and upholds the system of universal nature, evinces the like regard for the safety of man, by preserving, during his appointed term of years, the minutest parts, and most subordinate functions of his body. An unity of design pervades all creation, from the mighty and magnificent firmament of heaven, to the smallest particle of our corporeal nature; and so it is, that the Psalmist, in that song of praise[o] which our immortal Poet has put into the mouth of Adam[p], has called

[o] Psalm cxlviii. [p] Paradise Lost, book v.

upon sun, moon, and stars, fire and hail, snow and vapour, stormy winds and tempests, mountains and all hills, fruitful trees and all cedars, beasts and all cattle, creeping insects and flying fowls, to join in chorus to their Maker's praise. In like manner, the largest as well as the smallest, the simplest as well as the most complicated, the humblest as well as the highest, parts and portions of our mortal body should be made to join the great Doxology to their Creator and Preserver, and declare that His "is the Kingdom, and the Power, and the Glory." The venous system alone would be sufficient to supply themes for the universal hymn, and to swell the song of praise and thanksgiving by the loud-voiced testimonies of its internal provisions for the health, safety, and well-being of man.

Analogy between the declarations of Scripture and the evidences of minute anatomy as to the power, wisdom, and goodness of God.

Neither are these minute physiological wonders to be regarded simply and solely as natural evidences of the Divine perfections; they are also natural examples of what the word of God has declared and recorded, concerning the wisdom, power, and goodness of the Creator: they confirm, illustrate, exemplify, the declarations of the Bible respecting the fearful and wonderful workmanship of man's body, and the infinite wisdom, and boundless beneficence, and almighty power, of the Supreme Artificer. We know that Job, in his holy contemplations on the volume of nature, has sent man to the beasts of the field for a knowledge of the Creator's perfections, and says, "that the beasts shall teach him:" he sends him to the earth, and to the fowls of the air,

and to the fishes of the sea, and repeats upon each of his references, "that they shall teach thee, and tell thee, and declare unto thee," the same sacred truths: and in conclusion addresses this question to the hasty and heedless observer, "Who knoweth not that in all these, the hand of the Lord hath wrought this[q]?" So too may it be said, that every particle of our corporeal nature may serve for instruction; every component part of the absorbent, nutrient, sentient, circulating systems, will administer the like lessons. The veins, though they have neither speech nor language, yet their voices are heard among them, and (like the starry firmament) declare the glory of God[r]. The very valves of those veins, if with a Christian's auscultation we listen to their dictates, may be said to open their mouths in attestation of their Maker's wisdom, and pour forth streams of gratitude in acknowledgment of his benevolence and mercy.

All these testimonies harmonize with those of Scripture, the works and word of God join in the enunciation of the same sacred truths, "that the Lord is great, and great is his power, and his wisdom infinite[s];" that "He doeth great wonders, and that his mercy endureth for ever[t];" that "He upholdeth all things by the word of his power;" that "his tender mercies are over all his works[u];" that "in wisdom he hath made them all[x]." Under these joint assurances of Nature and Scripture; under the

[q] Job xii. 7—9. [r] Ps. xix. 3. [s] Ps. cxlvii. 5.
[t] Ps. cxxxvi. 4. [u] Heb. i. 3. [x] Ps. civ. 24.

testimonies to the wisdom, power, and goodness of God, tacitly given by the wonders of the venous, and especially of the valvular, system, and expressly by the declaration of the written word, the Christian physiologist will be led to exclaim in the words of Lawrence Bellini, at the end of his Treatise on the Motion of the Heart, "Magnus Fabricator hominum Deus! Magnus atque admirabilis conditor rerum Deus!! Quam Magnus es!!!" Or perhaps, finding no words but those of inspiration adequate to the expression of his convictions, he will ascribe "all honour and glory to the King eternal, immortal, invisible[y]," and conclude with the grateful acknowledgment, "that He is worthy to receive glory, and honour, and power, for He has created all things, and for his pleasure they are and were created[z]."

[y] 1 Tim. i. 17. [z] Rev. iv. 11.

T. C. RODEN.

MEMORANDUM.—*The Prize was awarded to the Writer, August* 25, 1838, *by the Judges appointed by Dr. Warneford's Deed of Trust.*

EDWARD JOHNSTONE, M.D. President of the Royal School.

The Rev. and Worshipful J. T. LAW, M.A. Vice-President, and Chancellor of the Diocese of Lichfield.

The Hon. and Very Rev. H. HOWARD, D.D. Dean of Lichfield.

The Rev. VAUGHAN THOMAS, B.D. Formerly Fellow and Tutor of Corpus Christi College, Oxon.

JOHN ECCLES, M.D. Physician to the General Hospital, and Lecturer on the Practice of Physic.

WILLIAM SANDS COX, F.R.S. Lecturer on Anatomy and Surgery.